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VARIAN

WATERLOAD
INSTRUCTIONS

Type V-4042A High Power

UHF Waterload

TECHNICAL INFORMATION

VARIAN associates
BOMAC DIVISION • Beverly, Mass.

VARIAN ASSOCIATES LIMITED

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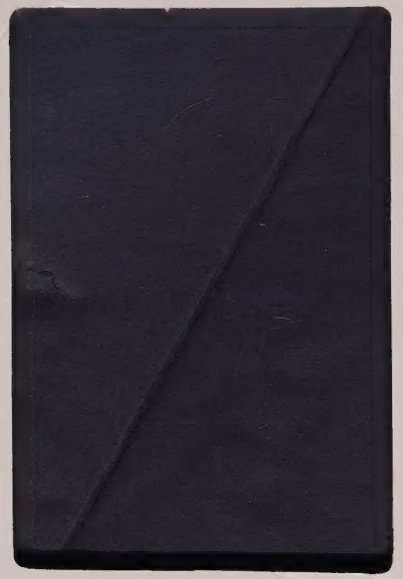
With Compliments

FOR THE ATTENTION OF MR SLEIGHT



MP MASTER
MA24430

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INSTRUCTIONS

Type V-4042A High Power

UHF Waterload

VARIAN ASSOCIATES
Bomac Division
Beverly, Massachusetts

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WATERLOAD

OPERATING INSTRUCTIONS

1. INTRODUCTION

These Operating Instructions provide the basic information for installing and operating Varian Waterloads. This information is to be used in conjunction with the appropriate Data Sheet, which furnishes characteristics, maximum ratings, operational data, and an outline drawing for that particular waterload. Accurate calorimetric measurements are obtainable with these specially designed loads which provide low loss walls, thermal isolation of the water, and elimination of rf leakage by rf shielding. The response time necessary to reach stability after a change in rf power is short because of the small volume of water in the load at any one time.

For additional information, please address inquiries to:

VARIAN ASSOCIATES
Bomac Division
Beverly, Massachusetts

2. PROTECTIVE MEASURES

Protective measures are necessary to assure that these loads operate within their published ratings. Normal waterload warranties apply only when Varian Associates determines that the ratings specified in the Data Sheets have not been exceeded and that the protective measures recommended in these operating instructions have been employed.

Mechanical Shock

Because the waterload contains glass tubing, it should not be dropped or roughly handled. The glass tubing is adequately protected against breakage during normal usage.

Bubbles in the Coolant

The water should have no bubble content. Bubbles in the coolant increase the voltage standing wave ratio (VSWR) which may cause electrical breakdown. Voids in the coolant increase thermal stress in the glass. Dissolved air tends to form bubbles as water temperature increases and as water pressure decreases. Bubbles

can be prevented if the load is operated with the proper water back pressure. Back Pressure can be obtained either by placing a constriction on the water outlet of the load or by maintaining sufficient pressure head on the outlet. Do not use a back pressure which causes the inlet pressure limit of the load to be exceeded. Special attention should be given to the back pressure used on loads equipped with flow regulators. Information on the head loss characteristics of these units can be found in the Data Sheets. Water suitable for safe operation may be provided by two methods:

1. Remove all of the gases from the water (by boiling, for example) and enclose the water in an air-tight recirculating system.

2. Place the water in a recirculating system where the water is freely exposed to air at one or more places.

The boiled water contained in closed systems may be used directly in the waterload. The water in the recirculating system can be used in the load only with the specified minimum back pressure. This minimum back pressure prevents liberation of the residual dissolved air in the load and is determined as follows:

1. Measure the temperature (^{o}C) of the water where it is exposed to air. If the system has several exposed places, the coolest temperature reading of the several locations is most significant.

2. Determine the required back pressure by referring to the curve in Figure 1 which indicates minimum back pressure as a function of the coolest water which is exposed to the air. As an example, if the lowest temperature reading is $20^{o}C$, then it is necessary to maintain a minimum back pressure on the waterload of 15 psig. The back pressure as prescribed by this curve is sufficient to prevent bubbles if the maximum water temperature at the outlet of the waterload does not exceed $75^{o}C$.

When the waterload is in use, the water temperature may change appreciably from time to time, necessitating periodic checks on the temperature of the water. These temperature changes should only cause concern when the water which is exposed to air is cooled. In an air-free, sealed system, such temperature changes are not important.

If only local domestic water, or a closed recirculating system containing aerated water is available, use as much back pressure on the load as possible without exceeding the recommended pressure limits. Back pressure should also be maintained when coolants other than distilled water are used. In some cases, the back pressure may not be sufficient to prevent the precipitation of air from the coolant.

CURVE OF MINIMUM BACK PRESSURE AS A FUNCTION OF TEMPERATURE OF COOLEST WATER EXPOSED TO AIR FOR OPERATING CONDITIONS WHERE THE EXIT WATER TEMPERATURE DOES NOT EXCEED 75° C.

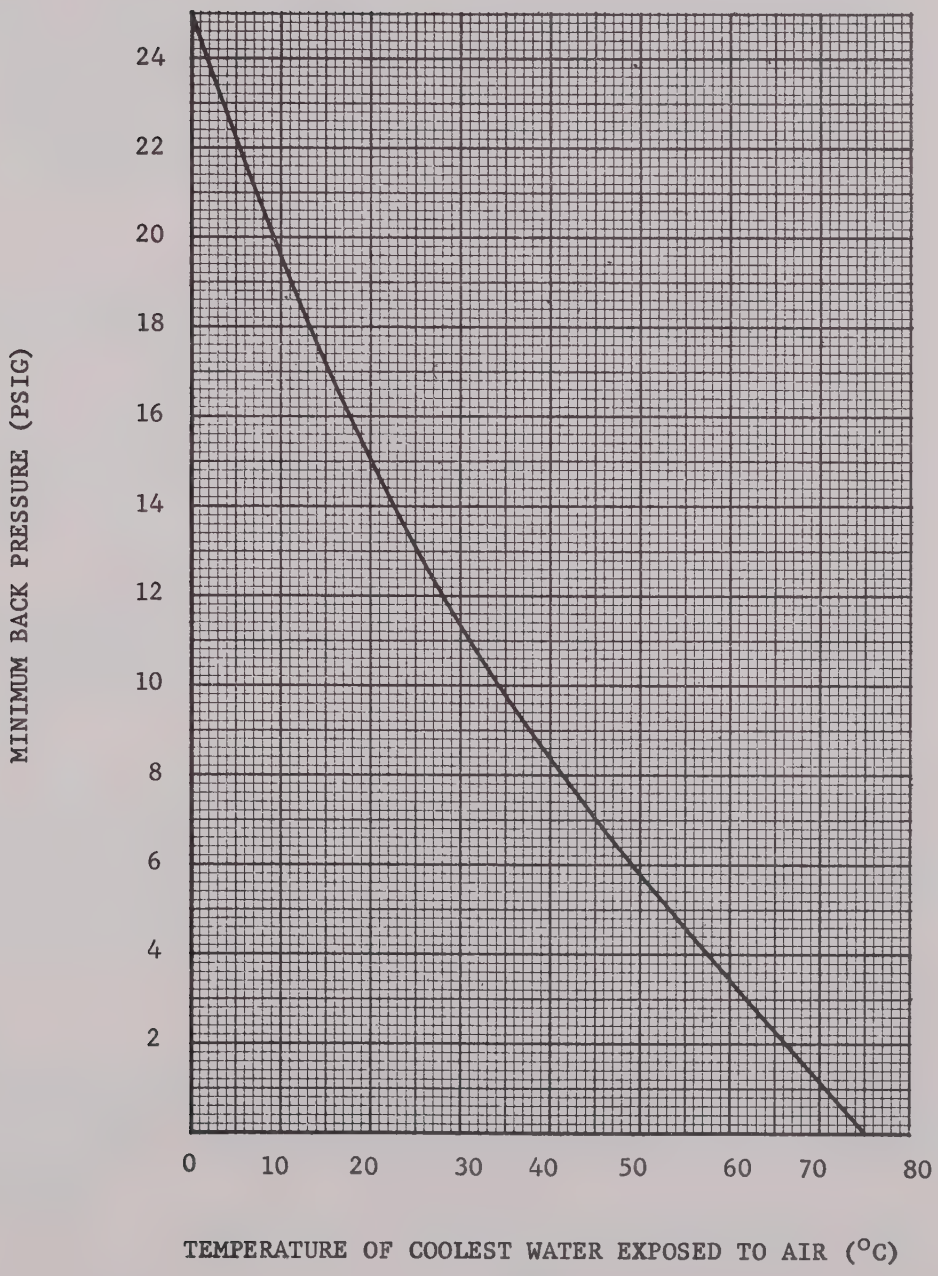


Figure 1

CAUTION:

IF BUBBLES ARE OBSERVED IN THE OUTLET LINE OF THE LOAD, DO NOT CONTINUE OPERATION.

Coolant Filter

To prevent particles from entering the load, a 120-mesh filter should be installed in the water inlet line to the load. This is especially important when the load is equipped with a flow regulator. If the water supply has an extremely high mineral content, a water softening unit will prevent harmful deposits in the load. If the coolant passes through a water softener, additional filtering should be unnecessary.

Air Removal

If the mounting position is not horizontal and the flow rate during operation is to be low, the load must be cleared of air before rf power is applied. The air can be removed from the waterload by alternately:

1. Inclining the load with the rf connector (flange) down and at the same time passing a moderate coolant flow through it.

2. Inclining the load with the rf connector up.

This sequence should be repeated until no air appears in the outlet lines. Traces of residual air will gradually dissolve in the coolant under correct conditions of back pressure.

Coolant Flow

The waterload should not be operated with a coolant flow rate so low that the outlet temperature limit will be exceeded. The water temperature increase can be determined from the equation on page 7. Some waterloads are marked with a preferred direction of flow, which is chosen to provide evenly distributed rf energy dissipation in the load or to initially clear the load of air.

Flow Meter

When the waterload is used for power measurements, a flow meter or indicator is necessary. Even if power measurements are not being made, a flow meter can be used to indicate that a sufficient amount of coolant is passing through the load for safe operation.

Flow Interlock

A flow-sensing interlock is recommended to protect the load and the rf power source from damage by overheating if the water flow to the load is stopped. Overheated water in the load can cause glass breakage, water inside the waveguide system, and a large impedance mismatch. Damage from this cause can be prevented by connecting the flow interlock contacts to the interlock circuit of the rf power source so that the power incident on the load will be removed when the flow is inadequate. Additional protection against release of water can be obtained through suitable use of electric valves with the interlock system as illustrated in Figure 2.

Pressure Gauges

Pressure gauges are required to monitor forward and back pressure on the load.

Pressure Regulator and Pressure Relief Valve

A pressure regulator may be required to prevent excessive water pressure on the load. For those loads which are not equipped with a flow regulator, a pressure regulator will aid in maintaining a constant water flow for purposes of power measurement. The pressure regulator may not be necessary if the pressure in the water main is constant and less than the pressure limit of the load even under static conditions. A fast-acting pressure relief valve may be used instead of the pressure regulator in those situations where constant flow is not important. The pressure limits of the load are stated in the Data Sheets.

Thermometers

Thermometers are required to monitor water temperature to and from the load. If the waterload is not used for power measurements, the inlet thermometer is not required. A thermometer should always be used to monitor the outlet temperature of the load. Means should be provided, if necessary, to make the temperature measurements which were discussed under Bubbles In The Coolant.

Storage

If the waterload is not used for an extended period, it should be drained. Never allow the coolant to freeze in the load.

3. INSTALLATION

Mounting

In most applications the waterload should be mounted horizontally or with the

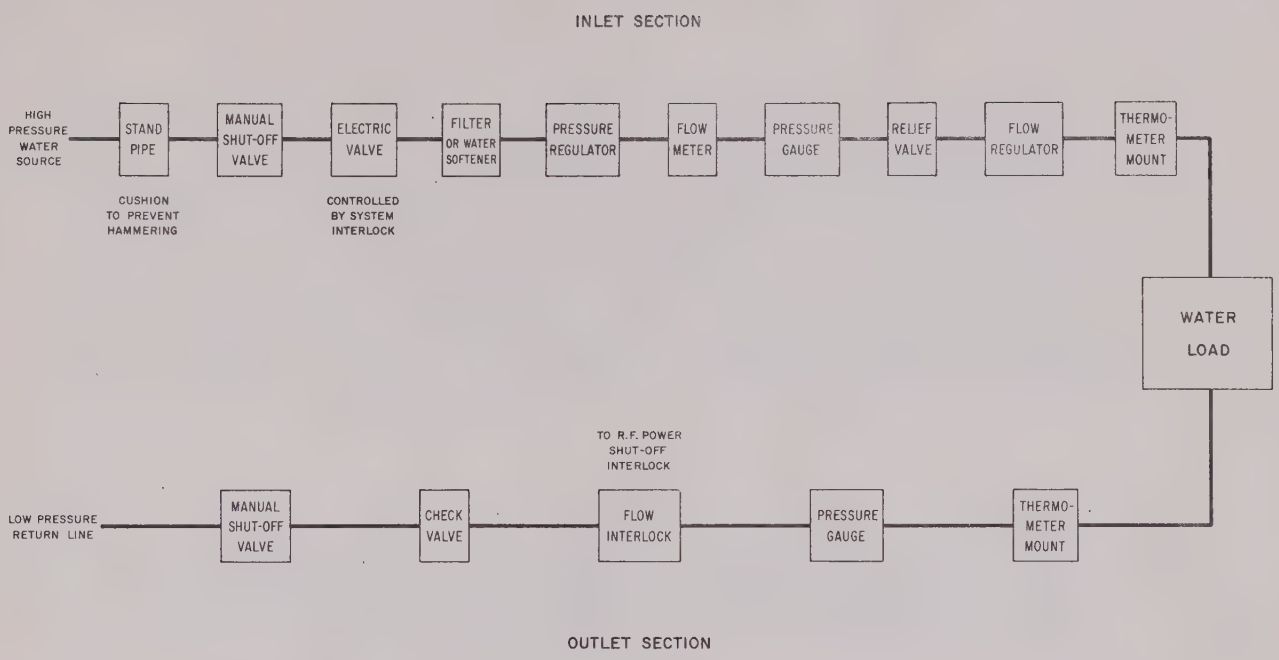


FIGURE 2

CONVENTIONAL WATER SYSTEM

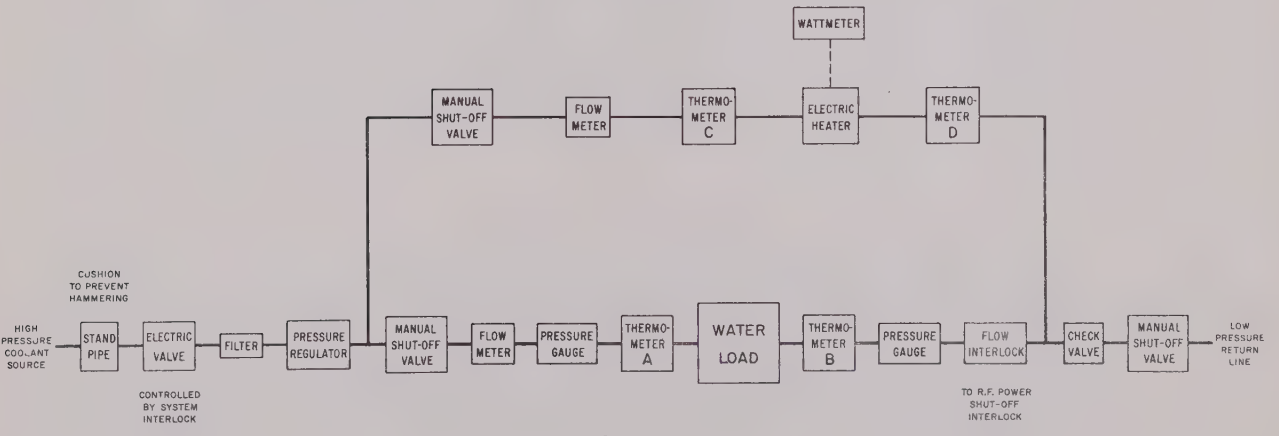


FIGURE 3

SPECIAL COOLANT SYSTEM FOR ACCURATE POWER MEASUREMENTS WITH COOLANTS OTHER THAN PURE WATER

outlet water connection end up to prevent trapping air in the coolant. When a substantial water flow is passed through the load, the angle at which the load is mounted is not critical. See the Data Sheets for specific mounting requirements. Damage to other equipment due to water leakage can be avoided by proper attachment of the load to the waveguide system. The tubing which the load fittings will accept is specified in the Data Sheets. If the load is equipped with thermometers which are attached directly to the water fittings, the thermometers should be removed while the tubing is being attached to prevent breakage. Thermometer removal is not necessary if the fittings are brazed to the load.

Water System

The flow and pressure requirements of the coolant system can be found in the Data Sheets. The components of a conventional water system are shown in Figure 2. In Figure 3 a special coolant system is shown for accurate power measurements with coolants other than pure water.

4. OPERATION

General

The temperature and pressure limits shown in the Waterload Data Sheets should never be exceeded. If the exterior of the load becomes significantly warmer to the touch than the waveguide preceding it or if the reflected power suddenly increases, remove the incident rf power immediately and examine the load for leaks. If the load has an internal leak, water will appear at the rf connector (flange) when the load is detached from the system.

Power Measurement

When the waterload is used as a calorimeter, distilled water is recommended, since its specific heat, density, and viscosity are essentially constant with changes in temperature. The flow regulator, which is attached to some loads, is calibrated only for distilled water. Calibration curves can be determined for the regulator when other coolants are used. Such calibration is very temperature dependent. The equation below is used to calculate average power with this waterload using distilled water:

$$P = 0.264\ (F)\ (T_2 - T_1)$$

where,

P = power in kilowatts

0.264 = a constant including the specific heat of pure (distilled)water

F = water flow in gallons per minute

T_1 = temperature of inlet water in degrees centigrade
T_2 = temperature of outlet water in degrees centigrade

To simplify this calculation the flow regulator has been calibrated directly in watts-per-degree centigrade. To find the power in watts, multiply the temperature difference ($T_2 - T_1$) in degrees centigrade by the number of watts-per-degree centigrade shown on the flow regulator dial.

EXAMPLE:
$\Delta T = 30^{\circ}C$. Flow = 500 $W/^{\circ}C$
$P = (30)\ (500) = 15,000$ Watts

To minimize heat losses in the lines, the thermometers should be connected as close to the load as possible. Errors due to thermometer miscalibration and heat losses in the load can be reduced if the coolant is passed through the load when no rf energy is being absorbed. The indicated temperature difference between the inlet and outlet thermometers should be considered in the rf power measurements. A differential thermopile may be used to obtain a direct indication of the temperature difference between the inlet and outlet water of the load. The thermopile must be periodically calibrated with thermometers to maintain reasonable accuracy. This technique will not measure temperature differences as accurately as thermometers, but its convenience may make it desirable in some applications. Thermopiles, like thermometers, should be located as close as possible to the load to minimize error from heat losses.

The specific heat, density, and viscosity of other coolants including hydrous mixtures will be markedly affected by changes in temperature and concentration. The system shown in Figure 3 can greatly decrease errors in power measurements when such coolants are used. The flow through the heater is adjusted so that the temperature difference across the heater equals the temperature difference across the load. The formula below is used to calculate the average rf power dissipated in the load.

$$P_L = P_{wm} \frac{F_L}{F_H}$$

where,
P_L = power dissipated in the load
P_{wm} = power dissipated in the heater (wattmeter indication)
F_L = coolant flow through the load
F_H = coolant flow through the heater

The flow meters must indicate accurately the ratio of the flow between each branch. Knowledge of the absolute flow is not necessary. Identical orifice type flow meters are recommended since most other types of flow meters in this application will not record the flow ratio accurately when the temperature and concentration of the coolant changes. Highest flow measuring accuracy is possible when a volume displacement technique is used.

The V-4042A Water Load is a high power dummy termination for 3-1/8 inch, 50-ohm, coaxial transmission line. Accurate power measurement can be made with this load by the addition of a flow meter[1]. The load dissipates average power up to a maximum of 15 kW in either CW or pulsed systems, over the frequency range from 470 to 1200 Mc. To achieve rapid response, rf energy is absorbed directly in a small quantity of water which encloses the center conductor within the load.

FEATURES

- High power dissipation.
- Low VSWR over a wide band.
- Rapid response to changes in rf power.
- Highly efficient energy conversion system.
- Complete rf shielding.
- Optional gas pressure sealing[2].
- Confined flow.

CHARACTERISTICS

Electrical

Frequency Range	470-1200 Mc
Average Power, max.	15 kW
Peak Power, max.	2 Mw
VSWR, over frequency range, max.	1.15:1
Time Lag, to reach stability after change in rf power	30 sec

Mechanical

Dimensions	See Outline Drawing
Weight	35 lb
Water Flow, typical for 15 kW [illegible]	[illegible] gpm
Water Pressure Drop, 2.5 gpm	28 psig
Water Temperature Rise, typical for 15 kW dissipation	23 °C
Inlet Water Pressure, max.	50 psig
Outlet Water Temperature, max.	70 °C
Mounting Position	Horizontal or inclined with rf connector down
RF Connector	Standard UHF flange for 3-1/8 inch, 50-ohm, coaxial line
Water Connectors (2 ea.)	Accept ½-inch I.D. rubber hose

SYSTEM REQUIREMENTS

A coolant system capable of providing 2.5 gpm at a pressure greater than 28 psig is required. When the water load is used as a dummy load, the coolant may be water-ethylene glycol mixture, water-alcohol mixture, etc. For use as a calorimeter, distilled water is recommended since the specific heats of the mixtures vary greatly with both concentration and temperature. Calorimetric techniques using coolants other than distilled water are outlined in the Operating Instructions.

Power is calculated by the following formula:

$$P=(0.264)\ (F)\ (T_2 - T_1)$$

where,

P=average power in kW

0.264=a constant including the specific heat of distilled water

F=flow in gallons per minute

T_2=temperature of outlet water, °C

T_1=temperature of inlet water, °C

THERMOMETERS

Inlet Temperature Range	-1 to +51°C
Outlet Temperature Range	+25 to +75°C
Scale Divisions	0.1°C

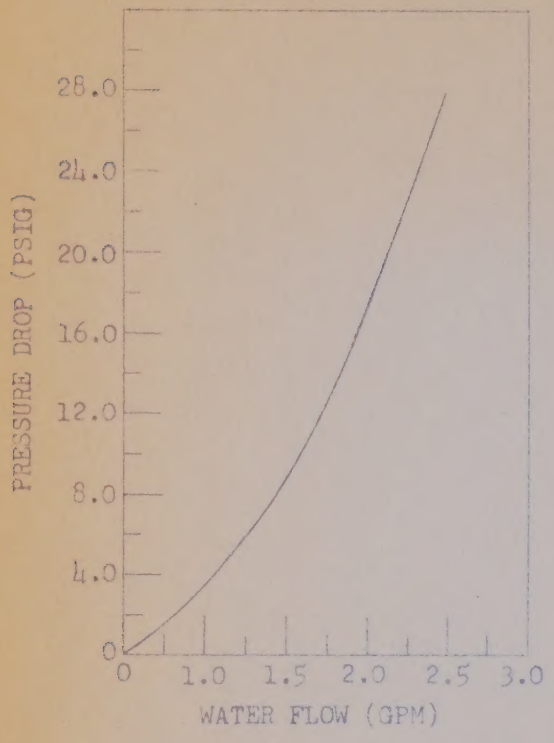
NOTES:

1. A variable flow regulator calibrated in watts per degree centigrade which can be attached directly to the load is available upon request at an increase in price.
2. A V-4042A water load capable of maintaining gas pressure to 30 psig is available upon request at a slight increase in price.

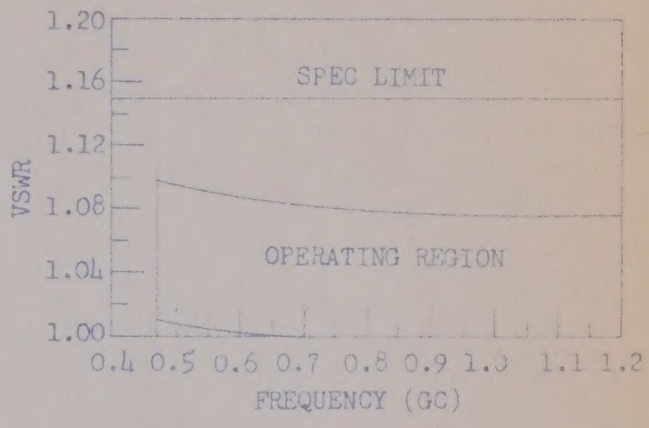
CHARACTERISTIC CURVES

All curves are average values

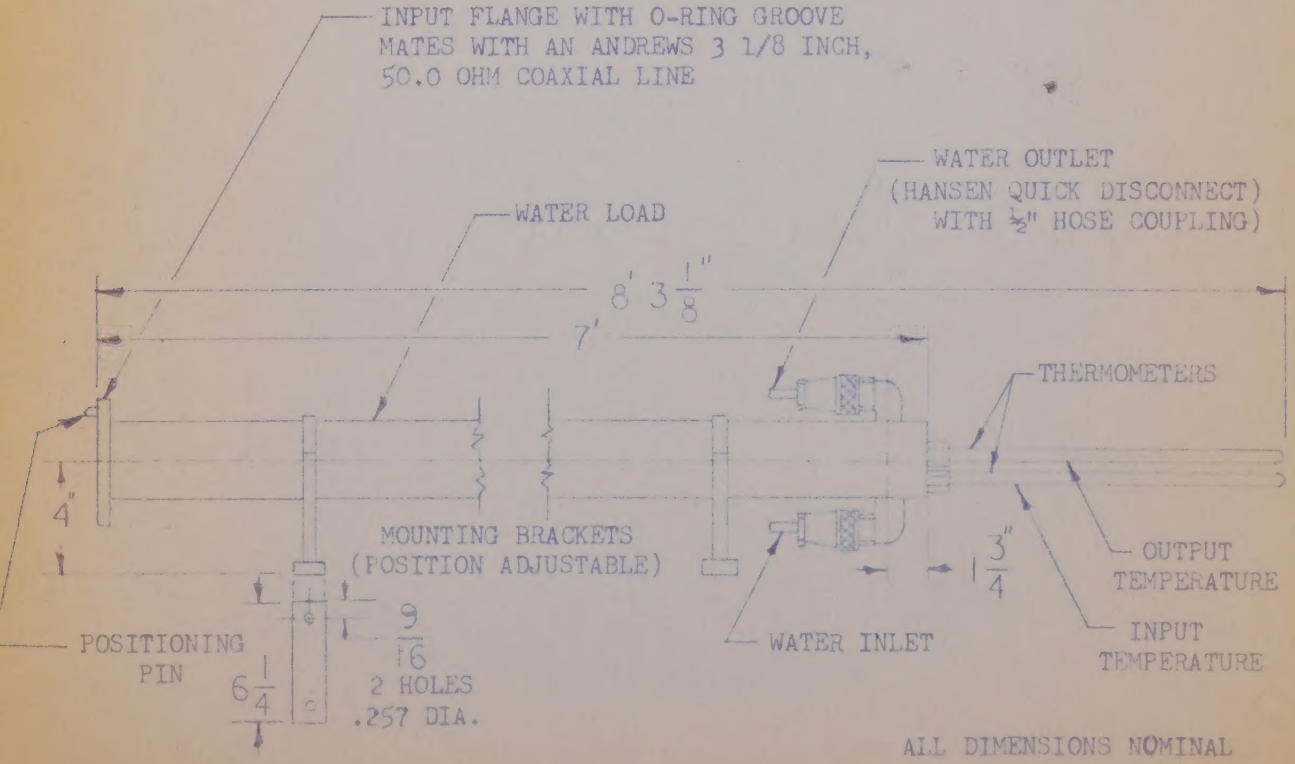
PRESSURE DROP CHARACTERISTICS



VSWR CHARACTERISTICS



OUTLINE DRAWING



ALL DIMENSIONS NOMINAL

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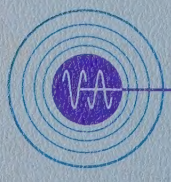

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